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Note

Reproductive biology of the commercially important Indian squid *Uroteuthis (Photololigo) duvaucelii* (d' Orbigny [in Ferussac & d' Orbigny], 1835) off Mangalore, south-west coast of India

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ABSTRACT

Uroteuthis (Photololigo) duvaucelii is one of the commercially important inshore squid resources off the south-west coast of India. Length-weight relationship for this species indicated no significant difference between the sexes and hence, the relationship for both the sexes was represented with the common equation $W = 0.4624\ L^{2.1158}$. *U. (P.) duvaucelii* spawned throughout the year with peak spawning in May. Absolute fecundity ranged from 1,545 to 13,585 eggs with an average of 7,554 eggs. Size at first maturity indicated that females matured earlier at 70 mm DML (dorsal mantle length) whereas males matured little later at 90 mm DML. Males were observed to be dominant during most of the study period with overall male to female ratio of 1:0.93. Seasonal and size dependent variations in sex ratio were distinct.

Keywords: Indian squid, Reproductive biology, *Uroteuthis (Photololigo) duvaucelii*

Cephalopod resources comprising of squids, cuttlefishes and octopus formed 5.64% of the total marine fish production of Karnataka State (CMFRI, 2015). Cephalopods were exploited by multiday trawl fleets (97.4%), single day trawl fleets (2.5%) and other gears (0.1%). Squids (72.5%) dominated the fishery followed by cuttlefishes (25.5%) and octopus (2%). The Indian squid, *Uroteuthis (Photololigo) duvaucelii* (d' Orbigny [in Ferussac & d' Orbigny], 1835) (67.1%) and the pharaoh cuttlefish, *Sepia pharaonis* (21.7%) were the major contributors (88.8%) in the cephalopod fishery. Among squids, *U. (P.) duvaucelii* formed 92.6% followed by *Uroteuthis (P.) edulis* (3.8%) and *Uroteuthis (P.) singhalensis* (3.6%) off Karnataka coast (CMFRI, 2015).

U. (P.) duvaucelii has emerged as one of the important components of trawl bycatch landings at Mangalore. On an average they formed about 5.9% of the total trawl catches off Mangalore during 1982-86 (Rao, 1988). Information on the biology of this species is very scanty (Silas *et al*., 1985). Hence detailed study was carried out on biological aspects of *U. (P.) duvaucelii* landed along the Mangalore coast.

The present study is based on the examination of 593 specimens (286 females and 307 males) of *U. (P.) duvaucelii* collected from Mangalore landing centre during August 2009 to May 2010. The samples were collected from commercial catches of trawlers operating in coastal waters in the depth range of 45 to 65 m. Dorsal mantle length DML (in mm) and the weight (in g) of the sampled specimens were recorded. Monthly length-weight relationships of males and females of *U. (P.) duvaucelii* were derived using the formula, $W = aL^b$. The male and female length-weight relationships were tested for significant differences by Analysis of Covariance (ANCOVA) at a significance level of 5%. The relative condition factor (Kn) was calculated sex-wise making use of respective length-weight relationship, using the formula: $Kn = Wo/Wc$ (LeCren, 1951), where Wo = observed weight and Wc = estimated weight. Month-wise relative condition factor was calculated for males and females separately. Chi-square test was used to test monthly effects on sex ratio at 5% level of significance.

For fixing the stage of maturity, Lipinski's (1979) universal scale (Juanico, 1983) was followed. For the purpose of estimating fecundity, the total weight of ovary nearest to one mg was taken. A part of the ovary was removed, weighed and the ova were counted under a binocular microscope. The total number of ova in the ovary was estimated by proportionately raising the number of ova in the sample to the total ovary weight.

Dorsal mantle length (DML) of the 593 specimens varied from 50 to 215 mm. The length-weight relationships obtained were:

Males : $W = 0.4771\ L^{2.1305}$ or $\log W = -0.3213 + 2.1305 \log L$

Females : $W = 0.4482\ L^{2.1012}$ or $\log W = -0.3485 + 2.1675 \log L$

Analysis of covariance (ANCOVA) indicated that there was no significant difference between the regression equations of males and females at 5% level. Hence the common equation for both the sexes was worked out as:

$W = 0.4624\ L^{2.1158}$ or $\log W = -0.335 + 2.1158 \log L$ (Fig. 1)

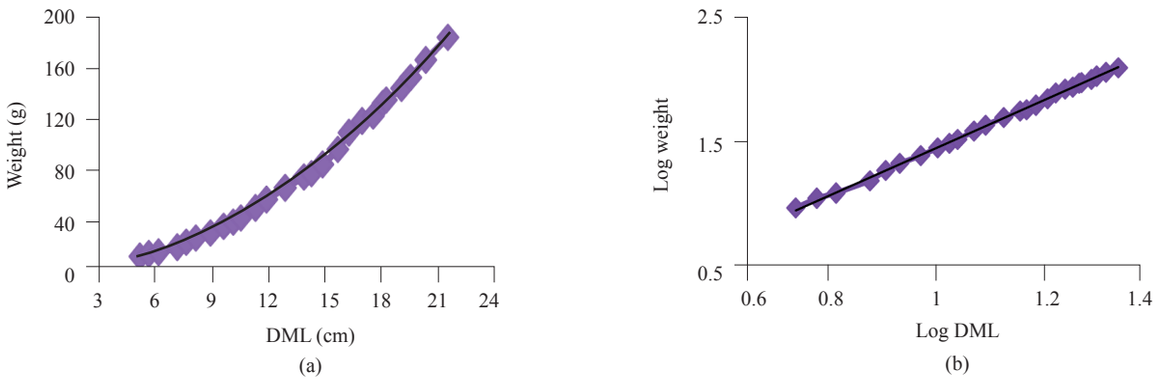

Fig. 1. Parabolic (a) and logarithmic (b) relationship between dorsal mantle length and weight of *U. (P.) duvaucelii*

The average Kn obtained for males was 1.0002 and that for females was 1.0022. In males, the Kn value was higher than the average during August, September, December, February and May while it was lower in the month of October, November, January, March and April. The Kn value was highest during December (1.0005) and lowest in the month of January (1.00). In females, the Kn value was higher than average during August and April, whereas, it was lower during September, October, November, December, January, February, March and May. The Kn value of females was highest during August (1.0092) and the lowest in the month of December (1.0001).

A perusal of data on the Kn values of males and females revealed that the relative condition was increasing up to 50-70 mm size group and showed a sudden decrease in subsequent size groups in males. However, Kn values reached a peak in 90-110 mm size group with a secondary peak at 130-150 mm size group. In later size groups, lower Kn values were recorded. In females, Kn values remained low in 50-70 mm group with a peak in 70-90 mm size group. It showed decreasing trend up to 130-150 mm size group with a higher value again at 150-170 mm.

Typical ovaries belonging to the four stages of maturity were selected and the percentage frequency distribution of ova diameters was estimated. In stage I, the ova ranged in size from 0.044 to 0.131 mm, majority of them being 0.09 mm. Size of the ova in stage II varied from 0.13-0.74 mm with a mode at 0.39 mm. In stage III, size of ova ranged between 0.56-1.61 mm. Maturing groups of ova are well demarcated from the immature ones from 1.26 mm size onwards with the largest measuring 1.60 mm. These are the ova which could be shed in water ensuring spawning season. In stage IV (spent stage), no eggs/degenerating eggs were found (Fig. 2).

Spawning season was determined based on the occurrence of mature individuals during the period of investigation. A total of 286 females and 307 males of *U. (P.) duvaucelii* were examined for this purpose. The data on maturity stages indicated that it spawned throughout the year with peak spawning in May. In August, September, October and November, stage I was predominant, whereas in the month of December, stages I and II were recorded

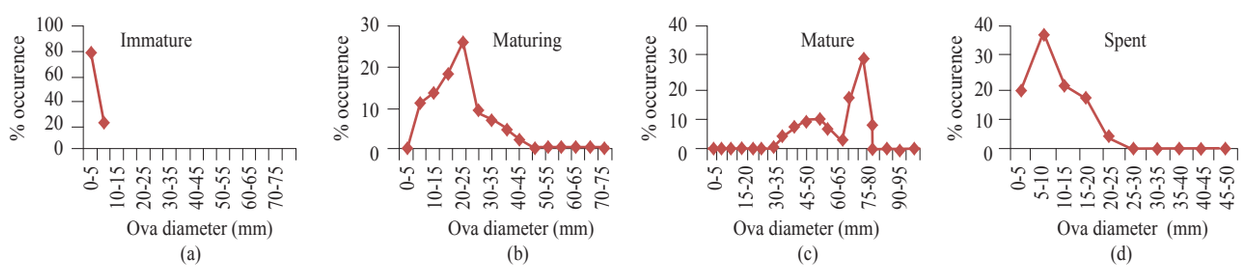

Fig. 2. Frequency polygons for ova diameter of *U. (P.) duvaucelii* at various maturity stages

in almost equal proportions while stage III showed an increasing trend as compared to previous months. In the months of January, February and March, stage II was dominant whereas stage III showed a decreasing trend. In April, all the stages were recorded with a dominance of stage II. However, stage IV was absent and stage III was recorded in higher proportion compared with previous months. In May, all the four maturity stages were recorded, with predominance of stage III.

Squids were grouped sex-wise into 20 mm groups and the percentage occurrence of squids in various stages of maturity was calculated. It was seen that all the females up to 70 mm were immature. Maturing stage started appearing from 70 mm onwards. Squids from the size group 70-90 mm (53.47%) were found to be mature. The size at first maturity of female squids appeared to be in the 70-90 mm size group. Mature males started appearing from 90 mm size group onwards and all male squids in 90-110 mm size group were mature. From this, the size at first maturity for males appear to be 90 mm.

For determination of size at first maturity, a total of 286 females were studied. Cumulative percentage frequency of II to IV stages were plotted against size groups. The size at 50% cumulative percentage frequency was considered to indicate the size at first maturity. The results indicated that the female and male squids matured at 70 and 90 mm respectively.

Values of the mean Kn values indicated that the size at first maturity is 90-110 mm and 70-90 mm for males and females respectively.

For the study of sex ratio, a total of 593 specimens were examined ranging in total length from 50 to 215 mm. Chi-square values at 5% probability level showed that there was no significant difference between months. The pooled sex ratio (male:female) was found to be 1:0.93. Chi-square test showed significant deviation at 5% level from the theoretical ratio of 1:1. Data on sex ratio in different sizes showed absence of females above 210 mm. This indicates that males grow to larger size than females.

Females were dominant only in the 50-70 mm, 70-90 mm, 130-150 mm and 170-190 mm size groups. Males were dominant in all the other size groups.

A total of 16 individuals in stage II and III were studied for fecundity. The data indicated that the absolute fecundity of *U.(P.) duvaucelii* ranged from 1,545 to 13,585 with an average of 7,554 eggs.

The linear relationship between log fecundity and log DML was found to be Y=-0.5386+4.0181X (Fig. 3a). The relationship between log fecundity (Y) and log body weight (X) of *U. (P.) duvaucelii* was observed to be linear (Fig. 3b). The linear equation derived was Y=0.9942+1.5332X. The relationship between log fecundity (Y) and log ovary weight (X) of *U. (P.) duvaucelii* (Fig.3c) was found to be linear with the regression equation estimated as: Y=2.0330+1.9051X

In the present study, the scatter diagram of weight against total DML of *U. (P.) duvaucelii* indicated the general pattern of allometric growth. The length-weight regression equation revealed that the weight of squid increased at a rate lower than the cube of length. The difference in regression co-efficient between male and female was not significant at 5% level. The value of b was found to be 2.1305 and 2.1012 for males and females respectively.

According to Rao (1988) there was good correlation between the length and weight at different stages of maturity. In general, the weight increment in females appears to be more than in males. Meiyappan *et al.* (1993) reported that the length-weight relationship of *L.duvaucelii* [=*U.(P.) duvaucelii*] inhabiting Indian coastal waters was $W = 0.000683\ L^{2.3789}$ and $W = 0.00037\ L^{2.5201}$ for male and female respectively. Mohamed (1996) also reported that both male and female *L. duvaucelii* inhabiting Mangalore area exhibited allometric growth. The relationship derived for male and female in his study were: log W = -0.31108 + 1.94514 log L and log W = -0.72000 + 2.32678 log L respectively.

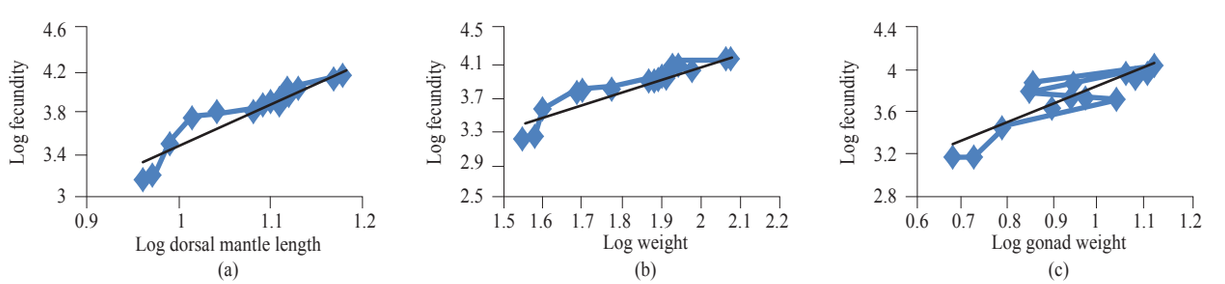

Fig. 3. (a) Dorsal mantle length and fecundity relationship, (b) Weight and fecundity relationship and (c) Gonad weight and fecundity relationship in *U. (P.) duvaucelii*

Data on seasonal variation in the condition of both female and male indicate that the values were highest in August. The lowest value was observed in the month of September and December for female and in January for male. This may be due to occurrence of higher proportion of immature and maturing individuals. Hart (1946) stated that 'K' values may give a very good idea of the seasonal cycle of a species. He observed that apart from the seasonal variation in condition, there could be a secondary variation related to the length of squid. With increase in age, there could be a lower level of condition throughout the seasonal cycle consequent to the increased metabolic strain for spawning activity.

Maximum occurrence of mature squids was observed in May. From the present study, it can be said that *U. (P.) duvaucelii* spawns over a prolonged period with peak in the months of April and May.

It has been reported that *U. (P.) duvaucelii* spawns throughout the year along both the coasts with peak spawning during post-monsoon period *i.e.*, September-November along the west coast of India (Kore and Joshi, 1975; Silas *et al.,* 1985; Mohamed, 1993). Silas *et al.* (1985) observed that squids with mature gonads occurred almost throughout the year all along the coast, indicating that spawning is continuous.

Present study revealed that the female and male *U. (P.) duvaucelii* attained maturity at 70-90 mm and 90-110 mm size range respectively. Rao (1988) reported that female and male *U. (P.) duvaucelii* attained maturity at 108 and124 mm respectively, along Mangalore coast. Silas *et al.* (1982) stated that the male squids attain maturity in the size range of 50-119 mm (76 mm) whereas females matured in the 70-139 mm (86 mm) size range, along the east coast of India. On the west coast of India, males were observed to mature in the size range 90-160 mm (113 mm) and females in 90-169 mm (118 mm) size range. The size at first maturity of male and female squid was 108 and 110 mm at Vizhinjam and 122 and 128 mm at Cochin respectively. Along the east coast of India, the size at first maturity for male and female squid was reported to be at 67 and 108 mm at Visakhapatnam and 85 and 96 mm at Madras respectively (Silas *et al*. 1985). Our study showed smaller size at first maturity for males at 90 mm as compared to the observation of Silas *et al*. (1985). Smaller size at maturity indicates either the effect of fishing pressure and/or the impacts of climate change in the region.

The sex ratio may reveal differential gear vulnerability for male and female (Kesteven, 1942). It may also indicate differences in the growth rate of two sexes (Quasim,1966). In the present study, data on sex ratio of *U.(P.) duvaucelii* showed that in most of the months males dominated over females with an overall male:female ratio of 1:0.93 which was significantly different ($p<0.05$) from the theoretical 1:1 ratio. According to Silas *et al*. (1985) females were dominant along Vizhinjam and males along Cochin. However along Mumbai coast, the sex ratio did not show any well defined seasonal changes.

Absolute fecundity of *U. (P.) duvaucelii* was found to vary from 1,545 to 13,585, with an average of 7,554. Logarithmic relations between fecundity and length, weight and ovary weight were found to be linear. Rao (1988) reported that the fecundity of *U. (P.) duvaucelii* ranged from 1,500 to 13,156, average being 5,284. Relation between length and fecundity and ovary weight and fecundity were found to be linear, with good correlation between length, ovary weight and fecundity. Collins *et al*. (1995) observed that fecundity of *Loligo forbesi* ranged from 2,500-10,500 with a mean of 5800 in Irish waters.

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